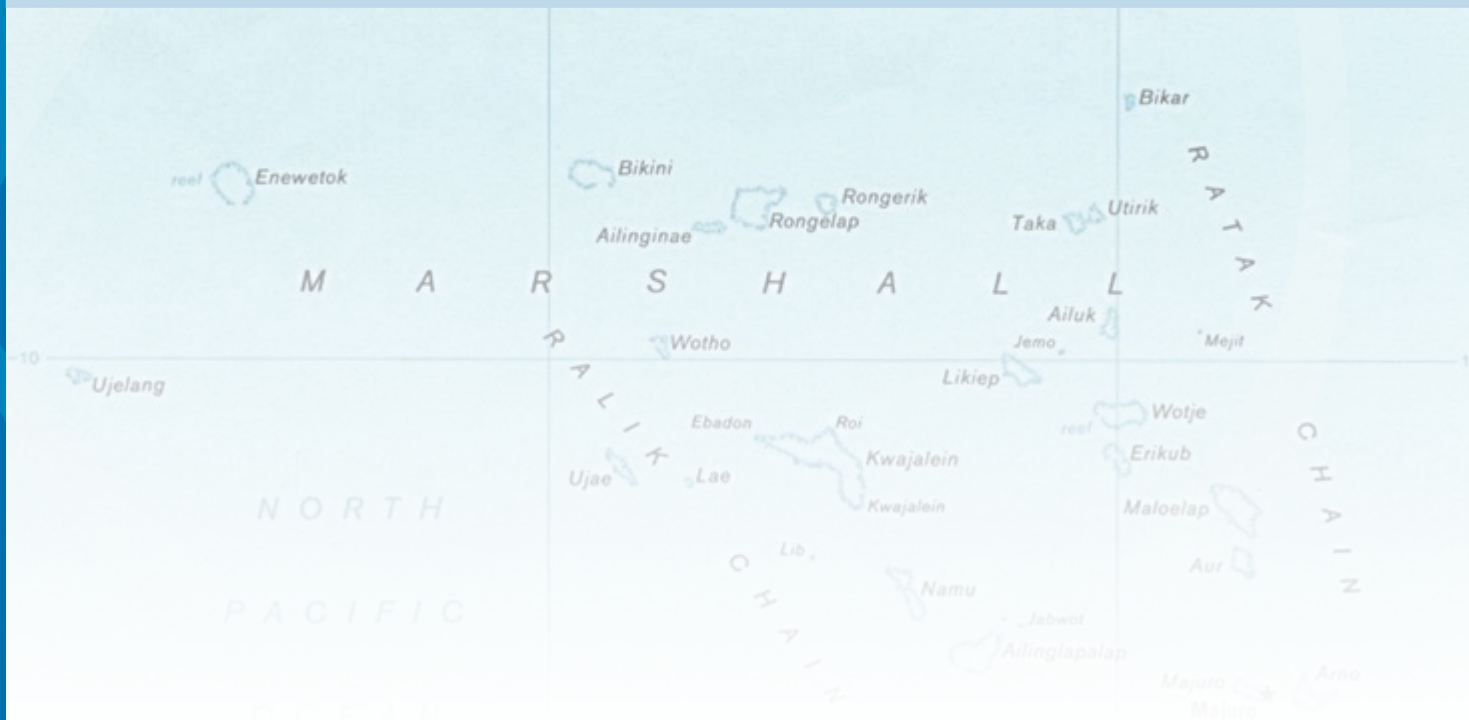
Report

IRENA
International Renewable Energy Agency

Pacific Lighthouses

*Renewable energy opportunities and challenges in the Pacific Islands region*

# The Republic of the Marshall Islands



## About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.
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## Disclaimer

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# The Republic of the Marshall Islands

August 2013

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***Note on currency:***
*The currency used in the Republic of Marshal Islands is United States dollar (USD).*

# Preface

In the Abu Dhabi Communiqué on accelerating renewable energy uptake for the Pacific Islands (of 13 January 2012), leaders from the Pacific Island Countries and Territories (PICTs) called on the International Renewable Energy Agency (IRENA) to "...map the Renewable Energy Readiness of the Pacific Islands Countries and Territories to ascertain the status of renewable energy opportunities and identify pathways to close gaps" and to integrate all IRENA activities in the region "...into a coherent roadmap for the Pacific Islands". In response, IRENA has carried out a wide range of activities of specific relevance and application to the PICTs as well as other Small Island Developing States (SIDS). This work has now been integrated into the IRENA report: ***Pacific Lighthouses: Renewable Energy Roadmapping for Islands***.

The report consists of an overview roadmap framework and 15 island-specific studies on the respective energy situations, and the challenges and opportunities for renewable energy deployment, around the region. These studies are available for the Cook Islands, the Federated States of Micronesia, the Republic of Fiji, Kiribati, the Republic of the Marshall Islands, the Republic of Nauru, Niue, the Republic of Palau, Papua New Guinea, Samoa, the Solomon Islands, the Kingdom of Tonga, Tokelau, Tuvalu and the Republic of Vanuatu. The IRENA Pacific Lighthouses report draws on those studies, as well as an additional study on a diesel-renewable energy hybrid power system, intended as a transition measure to a renewables-based energy future for the PICTs, which is also part of the series.

IRENA, in collaboration with its members and other key development partners, will continue to support the development national roadmaps and strategies aimed at enhanced deployment of renewables in the Pacific and other island states and territories.

# Acronyms

| | |
|---|---|
| **AC** | Alternating Current |
| **ADB** | Asian Development Bank |
| **ADMIRE** | Action for the Development of Marshall Islands Renewable Energies |
| **COFA** | Compact of Free Association |
| **EPD** | Energy Planning Division |
| **GDP** | Gross Domestic Product |
| **GEF** | Global Environment Facility |
| **JICA** | Japan International Cooperation Agency |
| **KAJUR** | Kwajalein Atoll Joint Utility Resource |
| **kWh** | Thousands of Watt hours |
| **kWh/gal** | Kilowatt hours per US gallon of fuel (fuel efficiency) |
| **LPG** | Liquefied Petroleum Gas |
| **MAEC** | Marshalls Alternative Energy Company |
| **MEC** | Marshalls Energy Company |
| **MW** | Megawatts (millions of Watts) |
| **NASA** | National Aeronautics and Space Administration |
| **O&M** | Operation and Maintenance |
| **OEPPC** | Office of Environmental Planning and Policy Coordination |
| **OTEC** | Ocean Thermal Energy Conversion |
| **PREFACE** | Pacific Rural Renewable Energy France-Australia Common Endeavour |
| **PV** | Photovoltaics |
| **RMI** | Republic of the Marshall Islands |
| **SHS** | Solar Home System |
| **UNDP** | United Nations Development Programme |
| **UNFCCC** | United Nations Framework Convention on Climate Change |

# 1. Country context

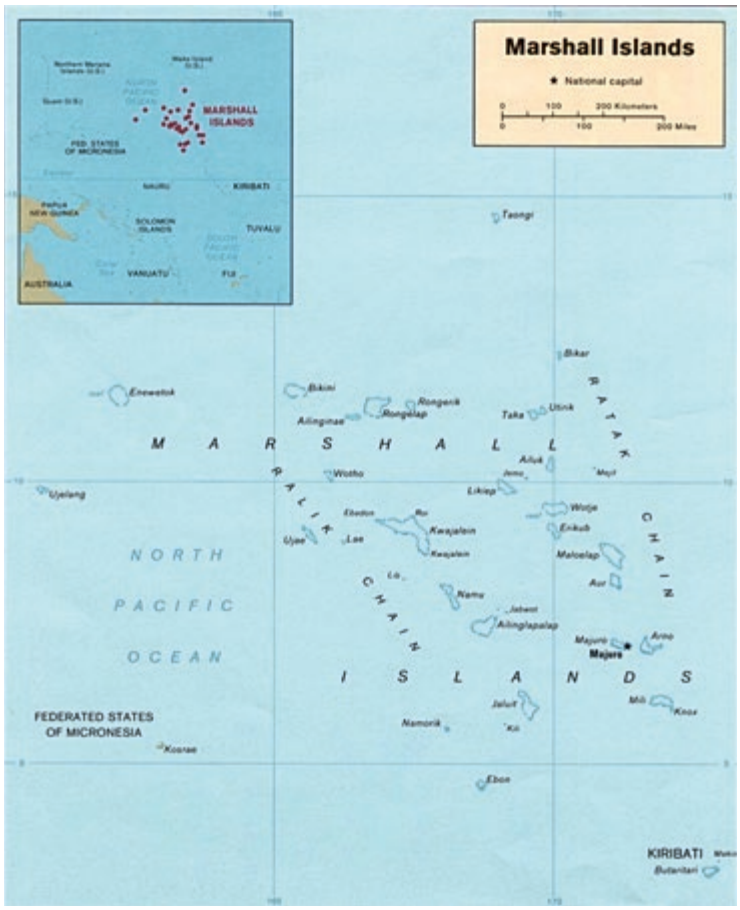


***Figure 1. Map of the Republic of the Marshall Islands***

*Source: http://www.lib.utexas.edu/maps/*

*The boundaries and names shown on this map do not imply official acceptance or endorsement by the International Renewable Energy Agency.*

**Physical description**. The Republic of the Marshall Islands (RMI) consists of two groups of atolls and islands – Ralik in the west and Ratak to the east – both located within a rectangle extending 1150 km north-south and 1300 km east-west, about 3200 km from Honolulu and Tokyo. Twenty-two of the 29 atolls, and four of the five small raised coral islands are inhabited. The islands are typically several kilometres long but rarely over 200 metres in width.

**Population**. In the 2011 census, the Republic of the Marshall Islands counted a population of 53 158. The island of Ebeye, where most workers at the U.S. military facility on Kwajalein live, is probably the most densely populated island in the Pacific. The 2011 census recorded 9614 persons living on the 0.31 square kilometres area of the island, giving a population density of 31 013 persons per km$^2$.

**Environment.** The climate of the RMI is moist and tropical with a wet season from May to November. The annual average temperature is 27°C, typically 30°C maximum and 25ºC at night, with relative humidity ranging from 76% at midday to 83% at night. Rainfall

is 1000–1750 mm in the north and 3000–4300 mm in the south. Infrequent tropical cyclones and droughts do occur although cyclones are rarely as intense as they are further west.

Land biodiversity in the RMI's atolls is among the lowest in the world but there is great diversity of life on the reefs. The Government has signed various treaties and conventions related to environmental protection, including several with energy implications such as the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. An initial communication to the UNFCCC indicating greenhouse gas emissions was submitted in 2000. In Majuro and Ebeye, environmental issues, related to rapid population growth and high population densities, include inadequate potable water and lagoons polluted by household wastes.

**Economic overview**. The RMI is heavily dependent on external assistance, grants averaging 60% of gross domestic product (GDP) since independence, mostly through the Compact of Free Association (COFA). As grant flows declined in the 1990s, real per-capita income fell below pre-independence levels. From 1990–2000, real GDP declined 1.6% annually. From 1995–2001, per-capita GDP dropped by nearly 35%. Unemployment is high and human development indicators are generally low, with income distribution being quite uneven and considerable poverty on the outer atolls.

A new 20-year COFA provides an opportunity for the RMI to shift toward economic self-reliance and is expected to contribute about USD 66 million per year (before inflation adjustments), about 60% of current GDP. The Asian Development Bank (ADB) notes an improvement in the economy since 2001 with 3% growth in 2002 and 2003, and about the same level in 2004 and 2005.

Much of the income on the outer islands comes from copra sales. However, over the years, low export prices have led to an interest in coconut oil as a locally sold biofuel. World coconut oil prices fluctuate greatly and Tobolar, the government-owned coconut processing company, exports vary accordingly. During periods of high export prices Tobolar has little interest in using coconut oil as a biofuel as the price is higher than diesel. Remittances from relatives on Majuro and pensions are also common sources of income for the outer islands.

# 2. Energy landscape

## Institutional and regulatory arrangements for energy

**The Energy Planning Division (EPD)**. The EPD is part of the Ministry of Resources and Development (MRD). It has full responsibility over the entire national energy policy framework and its associated action plans, overseeing: renewable energy; energy efficiency in both power supply and demand sides; petroleum reform towards energy efficiency; and the push towards an energy security plan linked to both national disaster management and energy supply security/management. This is a very broad responsibility, but the staff and resources of EPD are so small that in reality, it has to focus on immediately required actions and tends to deal mainly with projects, mostly relating to renewable energy and energy efficiency.

**The Marshalls Energy Company (MEC).** MEC is responsible for electric power on Majuro, operates the power systems of Jaluit and Wotje under a government contract. It also imports and distributes petroleum fuel products and installs, operates and maintains renewable energy systems in remote areas on a contractual basis.

**The Kwajalein Atoll Joint Utility Resource (KAJUR).** KAJUR generates and distributes electricity on Ebeye.

**The Economic Policy, Planning and Statistics Office (EPPSO).** EPPSO is the key national development planning agency and is closely involved in rural electrification policy.

**The Office of Environmental Planning and Policy Coordination (OEPPC).** OEPPC handles all Global Environment Facility (GEF) activities and all programmes under the UNFCCC in the RMI.

Renewable energy development has been *ad hoc* with various ministries taking responsibility for projects and independently establishing standards as well as operational and maintenance (O&M) procedures. There are still separate renewable energy activities within the EPD and the telecommunications, fisheries, health and education ministries.

**National Energy Policy and Energy Action Plan.** There have been numerous donor-assisted studies over the past 15 years resulting in various draft energy policy documents, including a 1994 Outer Islands Energy Policy (OIEP); a 2003 Marshall Islands National Energy Policy (MINEP); and the current National Energy Policy and Energy Action Plan that was adopted in 2009. The National Energy Policy was developed with the vision of "...an improved quality of life for the people of the Marshall Islands through clean, reliable, affordable, accessible, environmentally appropriate and sustainable energy services". It has the broad goals of:

- electrification of 100% of all urban households and 95% of rural outer atoll households by 2015;
- the provision of 20% of energy through indigenous renewable resources by 2020;
- improved efficiency of energy use in 50% of households and businesses, and 75% of government buildings by 2020; and
- reduced supply side energy losses from MEC by 20% by 2015.

The National Energy Policy and Energy Action Plans are scheduled for review in the second half of 2013.

Other relevant documents include a 1995 ADB outer islands electricity study that has been the RMI guide for rural electrification. A 2011 World Bank Micronesian Petroleum study shows the need for urgent petroleum regulatory and infrastructure reforms to sustain energy security and is expected to be a guide for petroleum management for the RMI for some time.

Although understaffing and capacity at the EPD could impact on the implementation of the policy, there prospects for renewable energy in the RMI are nonetheless promising owing to the broad acceptance of the ADB framework of rural electrification through solar photovoltaics (PV) over the past decade; the willingness and ability of MEC to manage renewable energy initiatives and accept grid-connected solar generation; the willingness of donors to fund needed projects; and the agreement between MEC and the Government specifying their respective responsibilities. At present MEC plays the *de facto* lead role in energy sector implementation and coordination.

The following laws or regulations directly or indirectly relate to energy sector matters:

- MEC Regulations designate Majuro as MEC's sole supply area, although there is no Electric Power

Act to regulate either MEC or KAJUR and no formal policy framework for national electrification.

- The Retail Price Monitoring Act provides powers to monitor and regulate retail prices but regulations have never been promulgated and there is no price control over petroleum fuels.
- The Unfair Business Act could in principle be used to monitor electricity and fuel prices but has not been used for this purpose.
- The Consumer Protection Act protects against unfair or deceptive business practices and could be used to regulate some aspects of renewable energy.
- The Bulletin Boards and Price List Act could be used to control fuel prices in outer islands but it is not enforced.
- The Alternative Energy Fund Act established a revolving fund for development, marketing and operation of alternative energy, but this no longer is active.
- The Import Duties Act specifies tax rates on all commodity imports (several energy efficient appliances and renewable energy components are exempted).
- The Environmental Protection Act provides powers regarding land use, pollution control and emissions.

## Energy supply and demand

**Petroleum.** The RMI is strongly dependent on imported petroleum fuels. Although there are no recent data on biomass consumption, it is estimated that about 92% of energy use in 2011 is from petroleum, biomass remaining significant but declining to about 2%, with on-grid and off-grid solar totalling around 6%. The main petroleum imports are gasoline, diesel fuel, dual-purpose kerosene (used as aviation turbine fuel and household kerosene), and liquefied petroleum gas (LPG). Mobil and MEC both provide products in Majuro, with Mobil supplying most outer islands with products except for distillate where MEC has a price advantage due to its large storage capacity. Mobil also provides aviation fuel. Despite the lack of price control, fuel prices (excluding duties and taxes) are about average for Pacific island countries.

In 2011, the RMI imported 56 million litres of petroleum fuel. Most of the storage facilities are owned by the overseas supplier although MEC also has its own large storage facility and imports diesel fuel for its own use and for selling to fishing vessels. From 2003 to 2011, the RMI lost 14% of its export volume, 26% of its marine bunker volume, to fuelling ships on the high seas and to the FSM. Until 2011, MEC purchased fuel outright, which often caused cash flow problems. However, in 2011 MEC secured a new supplier who was willing to deliver on a consignment supply basis, thus reducing MEC cash flow exposure and subsequently increasing diesel sales volume. Based on information for the years 2007 to 2011, 48% of imports are used for transportation and 52% for electricity generation. Kerosene demand is almost nil in RMI with increasing numbers of people using LPG for cooking and solar energy for lighting.

**Electricity generation and demand.** MEC supplies electricity on Majuro, Jaluit and Wotje and expects to eventually provide power to 28 other atolls. On some atolls, a local island committee operates generators and acts as a local utility company. On Majuro, before a power plant fire, MEC had 28 MW (nameplate rating) of diesel capacity de-rated to 18.2 MW. Maximum demand was about 8.5 MW in 2011. Sales of electricity from 2005-2008 are shown in Table 1.

In 2006 a major fire at the older power plant building on Majuro destroyed two engines and caused power outages and rolling blackouts until the other engines in the plant, which were not badly damaged, could be brought on line. Recently the lack of funds for maintenance, caused by being required to sell power below the real cost for many years, has caused a number of outages and operational problems. Generation grew 6.6% per year from 1999–2003 but recently growth has halted due to the increasing cost of power and power reliability problems.

*Table 1. Electricity sales 2005–2008*

| Year | Sector | Sales in MWh |
|---|---|---|
| 2005 | Residential | 27 517.26 |
| | Commercial/Industrial | 22 195.16 |
| | Government | 11 021.66 |
| 2006 | Residential | 26 997.36 |
| | Commercial/Industrial | 21 599.52 |
| | Government | 8 164.21 |
| 2007 | Residential | 26 087.05 |
| | Commercial/Industrial | 21 387.46 |
| | Government | 9 521.29 |
| 2008 | Residential | 22 852.11 |
| | Commercial/Industrial | 21 337.84 |
| | Government | 8 194.68 |

*Source: Provided through communication by MEC (2012).*

MEC customers on other islands account for only 5% of demand. In the fiscal year 2011 (October 2010 through September 2011), MEC generated 62 639 MWh of electricity, used 4 098 283 US gallons (15 513 689 litres) of fuel for an overall fuel efficiency of 15.24 kWh/US gal (4.038 kWh/litre). The peak load during that period was 8.75 MW. The actual electricity generation and fuel use between 2005 and 2008 are shown in Table 2. Figure 2 shows example load curves in December 2011.

In 2011, MEC had 2 629 standard residential meters and 462 residential pre-paid meters. Commercial meters numbered 462 and government meters numbered 145. The plan is to convert all residential meters to the pre-paid type as soon as possible. A new "scratch card" system is being introduced so that pre-paid meter customers can purchase payment cards at retail outlets, some of which are open 24 hours a day. Streetlights are unmetered and therefore show up as non-technical losses. Free electricity is provided to those persons whose land is used for transmission lines but this is metered and not considered part of non-technical losses.

The second-largest power system in the RMI is KAJUR on Ebeye. Recent data were not readily obtainable for KAJUR but available information indicates that it has an installed capacity of 4.8 MW and a peak demand of 2 MW. It has about 1 300 metred customers and generates 15.6 GWh of electricity per year using 4.2 million litres of fuel.

Table 3 gives a summary of all the public grids operating in the RMI in 2011.

**Electricity tariffs.** The current tariffs charged by MEC as of April 2012 are as given in Table 4. The most recent rates for Ebeye (KAJUR) are USD 0.33/kWh, USD 0.39/kWh and USD 0.40/kWh for residential, commercial and government customers, respectively.

Customers who have problems making payments on time can have pre-payment meters installed in order to avoid the disconnection and reconnection process and its associated charges, which in a number of cases have caused customers to remain off-grid once they have been disconnected.

*Table 2. Actual generation and fuel use 2005-2008*

| Year | Actual generation (MWh) | Fuel used (litres) | Station losses (MWh) |
|---|---|---|---|
| 2005 | 82 366 | 21 337 034 | 5 684 |
| 2006 | 79 077 | 20 602 327 | 5 304 |
| 2007 | 77 469 | 19 303 004 | 6 173 |
| 2008 | 70 696 | 17 623 641 | 7 726 |

*Source: Provided through communication by MEC (2012).*

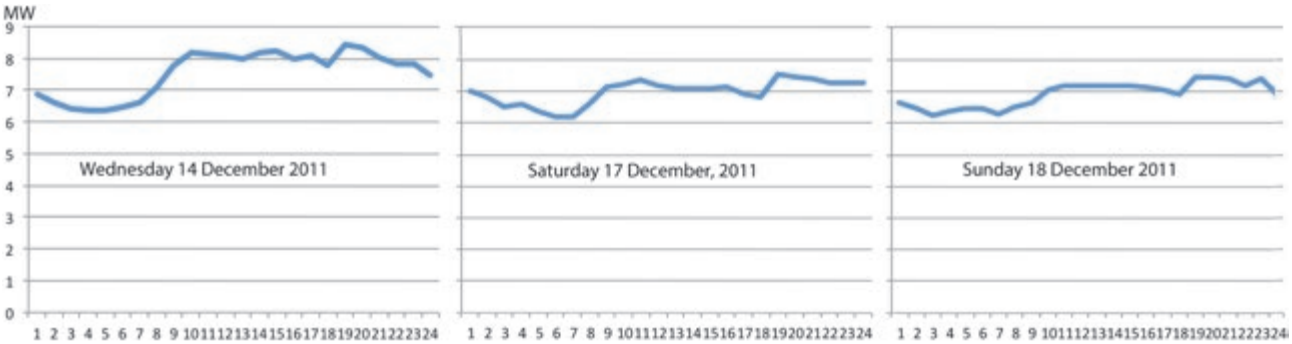


*Figure 2. Typical MEC grid weekday, Saturday and Sunday load profiles*

*Table 3. All public utility grids operating in the Marshall Islands in 2011*

| Location | Operator | Customers | Hours per day | Peak load time | kW peak | kW capacity | Generation source |
|---|---|---|---|---|---|---|---|
| Majuro | MEC | 3916 | 24 | 20:00 | 8500 | 18200 | Diesel |
| Ebeye | KAJUR | 1300 | 24 | 20:00 | 2000 | 4800 | Diesel |
| Wotje | MEC | 115 | 24 | 20:00 | 80 | 525 | Diesel |
| Jaluit | MEC | 110 | 24 | 20:00 | 90 | 525 | Diesel |
| Rongrong | MEC | 35 | 24 | 20:00 | 15 | 65 | Diesel |
| Kili | KBE1 | 130 | 24 | 20:00 | NA | 1500 | Diesel |
| Rongelap | RALGOV2 | NA | NA | NA | NA | NA | Diesel |

*Source: Provided through communication by MEC (2012) and MEC website for KAJUR.*
*1 KBE =Kili/Bikini/Ejit Government.*
*2 RALGOV = Rongelap Government.*

*Table 4. Electricity tariffs charged by MEC (2012)*

| Consumer type | | Tariff (USD/kWh) |
|---|---|---|
| *Residential* | 0–500 kWh/month | 0.41 |
| | > 500 kWh/month | 0.43 |
| *Commercial* | All usage | 0.49 |
| *Government* | All usage | 0.50 |

# 3. Renewable energy opportunities

Solar PV currently appears to be the most appropriate technology for electricity production from renewable energy in the RMI. Biomass, other than for cooking and copra drying, is not practical as a long-term energy source. Biofuels have considerable potential, since copra production is still the mainstay of outer island economies and coconut oil can be economically produced on a small scale. Wind is an unknown energy resource in the RMI although a wind resource measurement programme has been initiated. Wave energy and OTEC have long-term potential but both are in the development stage. There is no hydro potential, and no practical geothermal or known tidal energy development potential.

**Solar energy.** NASA satellite data for oceanic solar radiation are adequate for developing solar PV designs in the RMI. The resource appears to be greatest in the northern islands and least in the middle islands. However, there is an adequate solar resource throughout the country for cost-effective rural electrification through PV.

**Wind power.** There is a moderate seasonal wind resource in the RMI, with perhaps sufficient wind for energy development in the northernmost islands. However, there is very little data on wind conditions and none specifically designed for assessing its energy potential. It would be worthwhile assessing the wind energy potential for Majuro and Ebeye, where power demands are high. In 2012, two 34-metre wind resource assessment masts were installed in the outer islands to monitor and collect wind data.

**Hydropower.** There is no hydro resource in the RMI.

**Ocean energy.** Although there is clearly a good ocean thermal resource, Ocean Thermal Energy Conversion (OTEC) remains a commercially unproven technology and the economic size of a commercial facility – if one were ever built – would exceed the demand for all islands except possibly Majuro and Kwajalein.

At the RMI's low latitudes, wave energy is moderate. There are no commercially available wave energy systems operating, although there are designs in the developmental or prototype stage. Wave energy is unlikely to be a significant resource for the RMI in the near term. However, if the trial project for a 1.5 MW wave power farm using the Wavesurfer™ technology goes ahead in Kosrae in the Federal States of Micronesia and is successful, further trials in the RMI would be reasonable.

**Geothermal energy.** There is no known geothermal resource in the RMI.

**Bioenergy.** The poor soil quality and small land area of the RMI's atolls probably make large-scale energy production from biomass impractical. However an exception is coconut oil used as a biofuel to replace diesel fuel. Since copra production has been declining in recent years programmes to encourage production will be needed if this potential is to be realised.

If all the current production of copra were converted to oil, it would be equivalent to roughly 6% of the RMI's consumption of diesel fuel. Plans are underway to replace ageing coconut trees to increase copra production in the expectation that coconut oil demand will increase within a few years. Copra production in the last two years was 3600 tonnes annually with 3200 tonnes of coconut oil exported while 400 tonnes were used in Tobolar's boiler. In 2011 an ADB project included running one of the MEC's old Pielstik power generators on biodiesel. Plans to retrofit the engine from diesel to biodiesel are being prepared. However, coconut oil supply sustainability remains an issue for large-scale use.

There is also some potential for biogas production for cooking or small-scale power production from piggeries, if pigs were contained in a community holding area.

# 4. Experiences with renewable energy technologies

**Wind and biogas.** There were brief small-scale demonstrations of wind and biogas during the period when the RMI was under US administration, along with other Pacific countries, as the Trust Territory of the Pacific Islands but there have apparently been no further developments. The College of the Marshall Islands on Majuro has prepared plans to put wind turbines on the reef offshore from the college but they have yet to be installed. Some small wind machines are used for battery charging although there are no reports regarding their performance or cost of operation.

**Bioenergy.** Biomass remains an important resource for cooking and copra drying but there has been no commercial use of bioenergy.

**Wave energy.** In around 1990 the Kwajalein Atoll Development Agency (KADA) considered installing a 200–300 kW sea wave energy system on Gugeegue Island, near Ebeye. KAJUR was to purchase the electricity produced at USD 0.17/kWh, about double its actual value based on fuel costs at the time. The project was never developed and currently there are no plans for ocean energy development in the RMI.

**Solar energy before 2000.** During the Trust Territory of the Pacific Islands period, around 200 solar lighting systems were installed on various atolls. The island of Utrik received an experimental 120 V direct current solar mini-grid system that proved technically unsatisfactory and was later decommissioned. Most rural dispensaries received a solar refrigerator for vaccines and most atolls received one or more solar-powered high frequency radios, along with solar-powered lighting for public buildings and a few homes. However, few remained operational for more than a few years due to the lack of a suitable institutional structure for maintenance.

Fifty household lighting systems were purchased from BP Australia and were installed on Lae, Aur, Ailuk and Majuro in the late 1980s. Twenty-nine household lighting systems were purchased from Hawaii and installed on Arno and Ebon. In about 1993, the Pacific Islands Forum Secretariat installed 20 solar home systems (SHS) on Jabat. There were numerous technical problems with these systems but some continue to function and the project may be refurbished and operated by MEC in the future. In 1993, the Japan International Cooperation Agency (JICA) installed solar freezers for ice-making and fish storage on Ailinglaplap, Likiep and Namu atolls and expanded this facility in 1997. The systems operated until 2002, when there were failures due to corrosion. They were repaired by JICA a few years later.

**Institutional experience with solar.** The 200 systems installed during the US Trust Territory period were essentially gifts to households, who were expected to maintain them. A "rent to own" approach was tried in Maloelap (1995) and Aur and Ailuk (1992), where households were to pay USD 8–10 per month until the installations were paid for. Basic O&M was performed by a local technician with irregular visits from a Ministry of Resources and Development technician, and there were no disconnections for non-payment of fees. In 1996, the French government funded a SHS project, based on a solar utility concept, on Namdrik providing 134 home systems and six larger systems for refrigerators and streetlighting. The short-lived Marshalls Alternative Energy Company (MAEC) owned and maintained these systems, which used pre-payment metering charging users a monthly fee for the service. There were various technical, operational and social problems with this approach. The social problems included clashes with the island leadership from which a number of lessons were learned:

- Involve the recipient community, particularly its leaders, in planning;
- Pre-payment meters do not resolve earlier non-payment problems; and
- Complicated payment, institutional and technical systems are inappropriate for remote sites with poor communications and limited access.

## Recent projects and activities

**Biofuel.** Copra continues to be cut on outer islands as there is a subsidised incentive intended in part to reduce the population shift from rural to urban areas of the RMI. Although copra only contributes around 1% to GDP, encouraging its production is one of the principal ways of increasing employment and cash flows to the outer islands. Copra is shipped to the Tobolar oil mill on Majuro, which in 2010 produced 2 376 000 litres of coconut oil, and 3 952 800 litres in 2011, mostly for export.

The boiler at the Tobolar mill is fuelled by pure coconut oil although the company no longer uses coconut oil for its heavy equipment and vehicles. Tobolar used to sell coconut oil as a replacement for diesel fuel and had about 45 regular customers but discontinued sales after complaints about clogged fuel filters and other minor, but persistent, engine problems. MEC has undertaken short-term trials on Majuro of a coconut oil/diesel fuel blend with an old engine designed to use a wide fuel spectrum with good results and has plans for further trials on other island engines although these have not yet taken place.

After their persistent problems due to clogging of fuel filters and stuck injector pumps, Tobolar has incorporated a one micron filter and multiple stages for settling and water removal. In August 2012, in order to match export prices, Toblar sold its coconut oil locally at about USD 5.32/per US gallon compared with USD 3.50/per US gallon for diesel fuel. When global copra oil prices are high, it is more profitable to export than sell the oil locally as a biofuel. Tobolar naturally expects the best price for its product, which is a major problem for MEC if it plans to use biofuels as a diesel fuel replacement.

**Solar PV – off-grid.** Rehabilitation of the Namdrik PV project began in 2000 with funding from the Pacific Rural Renewable Energy France-Australia Common Endeavour (PREFACE), a project managed by SPC and funded jointly by France and Australia. Only the solar panels from the earlier Namdrik project could be salvaged. Even though efforts were made to integrate community leaders into the project fee payments were under 50% during the first year, partly due to people wiring around the pre-payment meters or to faulty accounting. Although MEC has taken over management, proper maintenance could not be provided since the government required that MEC charge only USD 5 per month for maintaining the systems, when the actual cost is several times that figure.

In 2002–2003, eleven health centres received solar systems from a UN trust fund. Unfortunately, the lighting was AC, which introduced significant losses and encouraged the use of additional appliances, which can overload the system. Inappropriate batteries were used, there was little interaction with EPD, minimal capacity building, and there was no mechanism established for maintenance.

The RMI requested support from GEF to develop a comprehensive programme for renewable energy capacity building and barrier reduction relating to solar PV, biofuel and wind. Funds were allocated for a programme called Action for the Development of Marshall Islands Renewable Energies (ADMIRE), but they have been seriously underused, and the United Nations Development Programme (UNDP), which managed the project for GEF, reportedly considered cancelling the project. In 2012, the ADMIRE programme shifted from OEPPC to the Ministry of Resources and Development.

Under the Cotonou Agreement (EDF-9), the RMI received an EU grant of about USD 2 million for renewable energy development and energy-efficiency measures. The funds were used to install PV installations as part of the outer island electrification programme. MEC has managed the project under government contract. The original institutional structure was one whereby sufficient fees were to be collected to pay for battery replacement and the cost of on-site maintenance. An installation charge of USD 100 was made, the monthly fee was initially set at USD 12 per month, and local technicians were hired by MEC and trained in maintenance.

In 2009, the government required the MEC to cut the monthly fee from USD 12 to USD 5, which would not pay for battery replacements, let alone other repairs, and the preventive maintenance that is vital for reliable power and long life for the battery. The government agreed to subsidise the difference but only paid the subsidy for the first year. Having received no further subsidy payments, MEC has no money to replace the high-quality batteries that are now starting to fail after only six or seven years of service. This discourages the further payment of fees since no repairs are being made even though fees have been paid. Fewer than 4% of customers were fully paid up in mid-2012 and, less than 50% were paying fees on time or at all. Some homes were disconnected for non-payment but most households that had not paid within the specified time were not disconnected.

The EU programme, combined with another donor programme from institutions from Chinese Taipei, has resulted in the installation of around 1500 solar home systems in residences and has provided solar electricity for six schools. Unfortunately, the design used was seriously flawed with the charge controller and sealed battery packed tightly into a metal box mounted on the pole supporting the panels. Since the box is exposed to the direct rays of the sun, the temperature in the box is high. There is no free airflow around the controller heat sink and, when combined with the high ambient temperature in the box, many have therefore had a short life. The high temperature in the box also seriously shortens the battery life.

These recent SHS installations include 200 Wp of panels, a Morningstar charge controller a sealed lead-acid battery and high-efficiency lights. Also included in the EU project are schools, which were electrified to provide AC power, as shown in Table 5. However if these systems are to survive over the long term, the government will have to allow an increase in fees or actually provide the large and continuing subsidy that has been promised. Since surveys have indicated that the cost of kerosene

*Table 5. School systems installed*

| School | Location | Size of Array | Battery Capacity (48V) | Approximate date of Installation |
|---|---|---|---|---|
| INE Elementary School | Arno | 6 kWp | 2100 Ah | 2009 |
| Ebon Elementary School | Ebon | 10.7 kWp | 1750 Ah | 2009 |
| Take Elementary School | Ebon | 8.9 kWp | 3000 Ah | 2009 |
| Mejit Elementary School | Mejit | 9 kWp | 3100 Ah | 2009 |
| Majkin Elementary School | Namu | 6 kWp | 2100 Ah | 2009 |
| Namdrik Elementary School | Namdrik | 12.8 kWp | 2100 Ah | 2009 |

*Source: Stapleton, G. (2012), Review of the Outer Island Electrification Programmes in RMI (Draft), SPC.*

for lighting is around USD 15 per month, shifting to solar at USD 15 per month should not have a detrimental effect on the cash flow of the outer island households. However, if the current situation continues, existing installations will only continue operating a few more years and any new systems installed will only survive until the original battery fails.

The Ministry of Education has opted to pay MEC a "per kWh fee" for energy provided to schools but will cover the cost of replacement batteries – the major on-going cost – themselves although it will rely on MEC to install the batteries and check the operation of the system.

As well as the approximately 1500 SHS to be installed in 2013 under the EU North-REP project, it is anticipated that another six schools will receive solar electrification and some existing, but older, health centre installations may be refurbished.

Eighty PV systems are planned for Mejit, similar to the Namdrik PREFACE installations of 2002. MEC will handle operations and maintenance.

**Solar PV – grid-connected.** As of mid-2012, only three-grid connected PV installations have been installed, all on Majuro. The first significant grid-connected PV installation uses a 57 kWp array mounted on the roof of the buildings of the College of Marshall Islands. The installation uses three bi-directional SMA inverters at 5 kW each and six 7 kW AC bus inverters. No batteries are included. The installation is reportedly working well and MEC has no problems with its connection.

The second installation is a grid-connected array of 209 kW at the Majuro Hospital. All the energy produced by the solar PV feeds directly to the MEC grid. The installation was funded by Japan and completed in 2012.

The third installation is a grid-connected array of 12.54 kW at the University of the South Pacific (USP) campus in Majuro.

# 5. Challenges for renewable energy deployment

The key barriers to renewable energy and energy efficiency in the RMI are:

- Limited capacity within the government to regulate, develop, implement and monitor renewable energy and energy-efficiency projects.
- Fragmented implementation of projects among government departments with little sharing of resources, information and experience.
- A lack of standards or certification for components and training.
- Irregular incomes on outer islands make it difficult for households to make regular cash payments.
- RMI's small size and its wide geographical distribution.
- Outer island villages are expensive to access.
- Loss of skilled people through emigration.
- Lack of good quality wind energy resource data.
- Donor-supplied equipment that is poorly designed for reliable operation in the tropical marine environment of the outer islands.
- Political interference that prevents full cost recovery for solar installations despite their being less costly than petroleum-based alternatives.
- Lack of confidence by users that the fees paid for service do result in good service.
- There is no programme for refresher training of technicians or for training of new technicians once installations are completed.
- MEC does not have a net-metering policy and current laws forbid generation by anyone but MEC, which makes it difficult for the private sector to participate.
- Lack of sustainability of the solar home systems provided by donors for the rural electrification projects.
- Maintaining a sustained copra supply for biofuel purposes.
- Lack of enforcement on fuel price regulation.
- Ageing petroleum infrastructure, which still represents over 90% of the RMI energy source.
- Need for local capacity development.
- Need for appropriate legislation to regulate energy security measures.

IRENA can suggest pathways to overcome these challenges through its Global Renewable Energy Islands Network (GREIN) and believes that regional and national roadmaps should reflect these pathways. IRENA will continue to work with existing regional and national stakeholders to achieve the transition to renewable energy for a secure and sustainable energy supply.

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